

# Reducing flood risks in rural households: survey of perception and adaptation in the Mekong delta

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**Abstract** The Mekong Delta, one of the most vulnerable regions to climate change, is the focus of international action for adaptation. Improved understanding of the exposures and perceptions at the local level will help residents to cope with natural disasters and future climate disruptions. In this study, we assess the exposure to floods that rural communities across the Mekong Delta are facing. Among the various natural disasters threatening the delta, extreme flooding is by far the most prevailing concern. By carrying out a field survey on 1350 residents, we characterize the flooding patterns and vulnerabilities of households in three geographically diverse provinces. The aim of this study is to assess the effectiveness of current flood adaptation in these households in conditions of regular flooding, as well as to extreme flooding events, which become more intense and frequent due to climate change. While the findings suggest varying degrees of coping with seasonal flooding by raising the ground floors of their homes, their capacity to prepare for extreme floods is limited in spite of the residents' awareness of the changing dynamics of natural disasters in their locality. We also examine their perception to the effects of climate change and identify factors that influence their awareness.

## 1 Introduction

Climate change poses the greatest risks to rural populations in the developing world (Adger et al. 2003). Those engaged in agriculture and aquaculture in Vietnam's Lower Mekong Delta, one of the most disaster prone areas in the world, are particularly vulnerable (Yusuf and Francisco 2009; Dasgupta et al. 2009). According to the country's Ministry of Agriculture and

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Rural Development (MARD) floods, along with typhoons and inundation, rank as the highest in frequency of natural disasters (Nguyen 2007).

As Vietnam strives to overcome poverty, the Lower Mekong Delta is undergoing rapid economic development; however, this has been hindered by an increasing number of climate driven disasters. For this reason, the region has been the focus of international aide and infrastructure development. The delta is home to over 18 million people or one-fifth of the country's population across 13 provinces, and encompasses nearly 40,000 km<sup>2</sup> in area. Lying in the "rice bowl" of Southeast Asia, most inhabitants of the Mekong Delta are engaged in rice production or aquaculture (Nhan et al. 2011). They produce half of the nation's agricultural output and 90 % of Vietnam's exported food.

For generations, the residents of the delta relied on regular floods to irrigate their crops and feed their fishes. Seasonal river flooding, which coincides with the rainy season that runs from May to November, plays a critical role in the health of the Mekong river system. These floods deposit sediments, which improve soil fertility, flush out polluted waters, and recharge the groundwater tables. The implementation of irrigation and drainage systems to supply fresh-water for agriculture can be traced back to the Canal Vinh Te, built under new Nguyen Dynasty from 1819 to 1824 (Tuan et al. 2008). Since the end of the Vietnam War, the country has continually built new canals, sea dykes, and sluices to manage floods, to store water for drought seasons, and to prevent salt water from intruding into their croplands and swamping their homes. These developments have enabled the delta's population and agriculture to grow (Wassmann et al. 2004). In addition, poldering has been employed to increase agricultural capacity by enclosing floodable land with levees (Vu et al. 2014).

Yet, excessive flooding during the rainy season and severe droughts during the dry season are becoming more frequent, and structural elements are not expected to hold up under an increasingly severe climate regime, which is driving sea-level rise (SLR) and changing meteorological and hydrological conditions. Moreover, progressive poldering has raised flood risks by increasing the water level when compounded with SLR (Vu et al. 2014). Monitoring stations show an average sea-level rise of three mm per year, in line with the global average rate of increase (World 2010a). As the entire region is a flat flood plain with a maximum elevation of five meters and typically less than two meters, the Mekong Delta is strongly sensitive to the changing dynamics of the East Sea (South China Sea) and West Sea (Thailand Gulf). Recently, SLR is causing the tides on the East Sea to rise over two meters, obstructing discharge of water from rivers and causing seawater to intrude upstream (Van 2011). As a result, the main rivers are expected to rise, causing flooding over wider areas and longer durations. Measurements of the water level in estuaries of the Mekong Delta show the highest recorded levels in recent years.

Together with stronger winds and heavier average rainfalls in the Mekong Delta (Christensen et al. 2007), the impacts of SLR on inundation and drainage are especially severe around coastal and agricultural areas (Wassmann et al. 2004; Dasgupta et al. 2009; Truong et al. 2011) with some areas showing as much as 100 m of seawater intrusion. With higher salinity, rice productivity is severely affected; however the sector has made strides in adaptation through the development of salt tolerant varieties (Linh et al. 2012). Nevertheless, these disasters cause extensive damage to housing and infrastructure, and communities that were once thought to be safe from flood water are now prone to inundation (MONRE 2010; Truong et al. 2011). Moreover, powerful tropical storms that drive severe floods along the coastlines and rivers destroy thousands of homes each year. The Mekong River Commission (MRC) anticipates the sea level to rise by another 0.8 to 1.0 m by 2100 under current trends. In this scenario, up to 38 % of the Mekong Delta will be underwater and 30 % of the residents would have to migrate away (MRC 2011).

With limited success, the government has taken structural and non-structural approaches to improve adaptive capacity. In 1996, the national government initiated its Living With the Flood (LWF) program to relocate residents from flood areas and to build housing for resettlement (UNDP 2008; Danh and Mushtaq 2011). While more than one million people have been relocated, about half of the residents in the delta still live in flood zones (Nguyen 2007). Among them, 2.5 million live in deep flood areas (up to 3.0 m) and 3.0 million live in medium flood areas (up to 1.5 m).

In contrast to top-down approaches like LWF and the building of dykes and other infrastructure, bottom-up planning to adaptation by residents is also needed (Tuan and Chinvano 2011; Pielke et al. 2012; Tamura et al. 2014). While scientific projections provide a framework for understanding and managing the effects of climate change, assessing climate impacts on the ecology, agriculture, and livelihoods at the community and residential levels helps to identify appropriate adaptation responses (Klein et al. 2000; Smit and Wandel 2006). In addition, how climate change is perceived in these communities can inform and drive action towards taking appropriate measures to reduce climate driven risks (Francisco et al. 2008; Tinh et al. 2010; Dang et al. 2013).

Using rural villages in the Lower Mekong Delta as a case study, we aim to:

1. Compare the relative heights between ground floor levels and flood height levels in the most disadvantaged communities
2. Assess the state of adaptation in households
3. Evaluate residents' perception to changing flood exposure
4. Identify factors shaping local perceptions

International programs in the Mekong Delta (World 2010b; DWF 2011; ADBAusAid 2011; ADB 2012) have focused on understanding climate change and the adaptation measures at the provincial or district levels. However, these efforts focus on populations that are easily accessible. Other studies have examined vulnerabilities in households (Birkmann et al. 2012; Kobayashi et al. 2012; Nguyen and James 2013; Dang et al. 2014).

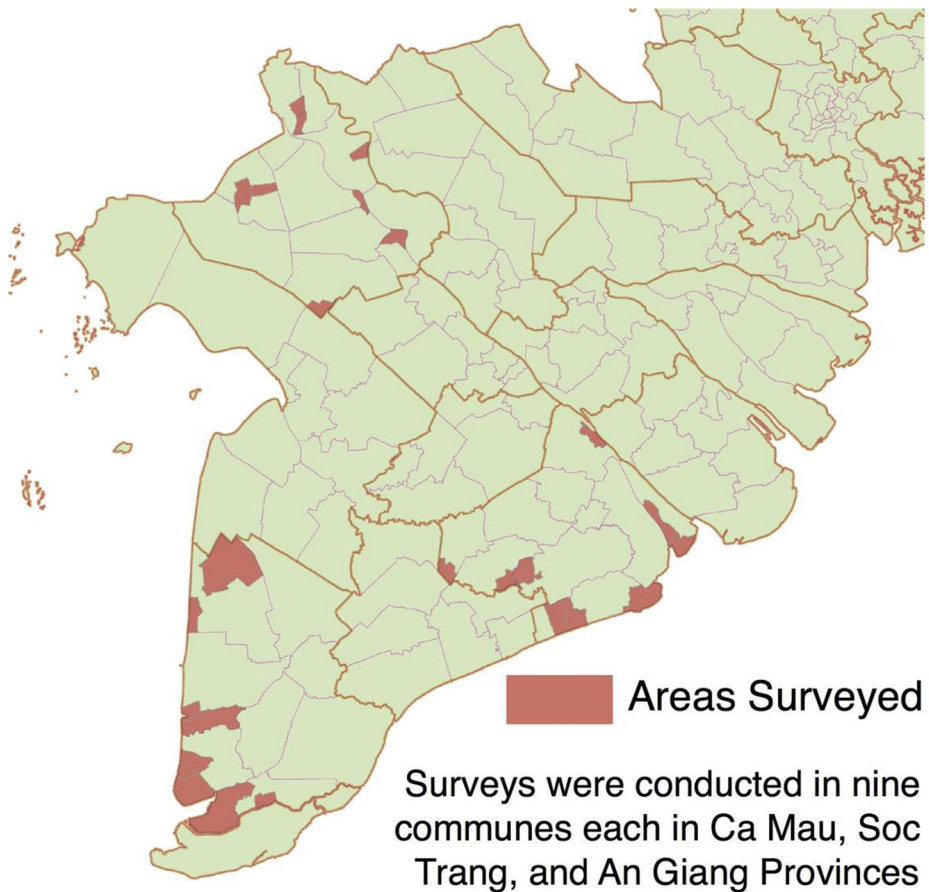
In contrast, this study examines the linkages among exposure, perceived flood risks, and adaptation in vulnerable communes of the Lower Mekong Delta and identifies the factors contributing to adaptive capacity.

## 2 Methodology

### 2.1 Description of survey sites

Upon consultation with our research counterparts at the Water Resources University (WRU), Vietnam, three provinces (An Giang, Soc Trang, and Ca Mau) were chosen for this study (Fig. 1), based on various factors, including their socioeconomic circumstances and their diversity in geography and meteorological conditions (Table 1). This research goes beyond earlier studies, which have generally focused on Can Tho, the geographic and economic center of the delta.

In a study supported by the World Bank in 2011, it was found that the residents of Can Tho reported little impact to their livelihoods during that year's flood season (DWF 2011). While flood heights were among the highest recorded, daily activities continued almost as normal and



**Fig. 1** Location of communes surveyed in the Vietnam Mekong Delta

the situation was generally accepted as routine in the delta. Due to its relatively advanced state of development, Can Tho is not only highly urbanized, it has greater access to resources and services to cope with disasters.

In contrast, the provinces selected for this study represent the general socioeconomic state of the majority of the Lower Mekong Delta. Not only are the per capita GRPs (gross regional products) up to a third lower than that of Can Tho's, the extent of urbanization is less than one-third in contrast to about two-thirds for Can Tho (Table 1). In 2011, the per capita GRP in Can Tho was 48.9 million VND, far higher than the 28.0 million VND average for the entire Lower Mekong Delta.

Located at the northwestern part of the Mekong Delta and sharing a border with Cambodia, An Giang experiences deep riverine flooding due to overflow of the Tien and Hau branches of the Mekong River. With numerous tributaries and extensive canals that criss-cross the province, the floodwaters are being harnessed to enable as many as three rice crops per season. Record flood levels in 2011 due to unprecedented series of storms and typhoons, led to 19,000 homes being flooded and 54 schools submerged (UNICEF 2011).

Soc Trang, which lies downstream of An Giang and on the East Coast of the delta, is directly affected by tidal effects that are being exacerbated by SLR (Wassmann et al. 2004;

**Table 1** Profile of provinces surveyed. Can Tho is added as a reference

	An Giang <sup>a</sup>	Soc Trang <sup>b</sup>	Ca Mau <sup>c</sup>	Can Tho <sup>d</sup>
Area (km <sup>2</sup> )	3536	3311	5294	1409
Agriculture (km <sup>2</sup> )	2974	2765	4628	918
Population	2,151,000	1,304,000	1,216,000	1,200,000
Rural / Urban (population ratio)	72/28 <sup>e</sup>	81/19 <sup>e</sup>	80/20 <sup>e</sup>	34/66 <sup>e</sup>
Districts	9	11	9	9
Wards	156	109	101	85
GRP per capita (1000 VNDs)	27,360	28,549	23,399	36,000
Annual rainfall (mm)	1400 to 1500 <sup>f</sup>	1700 to 1800	2500	1600

<sup>a</sup> An Giang Statistical Office “Statistical Yearbook An Giang Province 2011” June 2012

<sup>b</sup> Soc Trang Statistics Office “Statistical Yearbook 2011” 2012, Statistical Publishing House

<sup>c</sup> Ca Mau Statistics Office “Statistical Yearbook 2011” April 2012

<sup>d</sup> DWF “Survey on Perception of Risks in Can Tho City” 2011

<sup>e</sup> Central Population and Housing Census Steering Committee “The 2009 Vietnam and Population Census: Completed Results” June 2010, Statistical Publishing House

<sup>f</sup> An Giang Government Website: <http://english.angiang.gov.vn/>

Le et al. 2007; Kuenzer et al. 2013). The province faces a combination of a monsoon climate, upstream flooding and high tide of the East and West Seas. These are leading to both saline intrusion and salinization, as well as sea and river bank erosions (CARE Australia 2012). Local residents are vulnerable to breaches in their dykes as higher tides and stronger waves from the sea exceed the capacity of these structures (Tang 2013). Soc Trang residents rely on both rice farming and fisheries for their livelihoods.

Lying at the southern tip of the Mekong Delta is Ca Mau, which consists of salty marshland and freshwater wetlands, as well as small island clusters offshore. In spite of its temperate climate, Ca Mau is extremely vulnerable to widespread flooding due to its unique geography, a flat terrain no greater than 1.0 m in elevation, coupled with complex interactions between salt-water and freshwater regimes. Coinciding with the rainy season, strong winds and cyclones can inundate dyke routes, residential and agricultural areas, erode banks and contaminate drainage (SIWRP 2009). The residents of Ca Mau largely rely on fish and shrimp farming for their income.

## 2.2 Method of survey

In this study, we worked with WRU to conduct a questionnaire survey on local residents. In each province, nine of the most vulnerable communes/villages, as identified by the authorities at the provincial Department of Agriculture and Rural Development (DARD), were selected. These selected sites do not represent the province as a whole but are consistently known for vulnerabilities. The areas surveyed in An Giang are known for damages caused by severe erosion while areas in Soc Trang are highly affected by SLR and storms. In Ca Mau, we examined communes, which are also the target of a concurrent study (Tamura et al. *under review*), being inundated due to SLR.

Table A.1 shows the list of communes that were surveyed. While we acknowledge that the selection of the residents is not completely unbiased, they are not based on accessibility but on

the experts' opinion at DARD to randomly select for households that are typical of local geographical and socioeconomic conditions.

In each commune, the students of WRU surveyed 50 families by visiting their residences and verbally interviewing them, using a questionnaire that was based on the one designed by DWF (2011). A total of 1350 households (nine communes  $\times$  50 residences/commune=450 in each province) were visited over a period of two weeks in November 2012, and the students recorded the answers on paper. Basic geographical, demographic, and socioeconomic information was asked along with those specifically relating to their housing situation, their experience with floods and other natural disasters, their perception of climate change, and their ability to cope and adapt to these changes.

The data was analyzed to understand the flood profiles and adaptation strategies among these three provinces.

### 3 Results and discussion

#### 3.1 Socioeconomic background of households

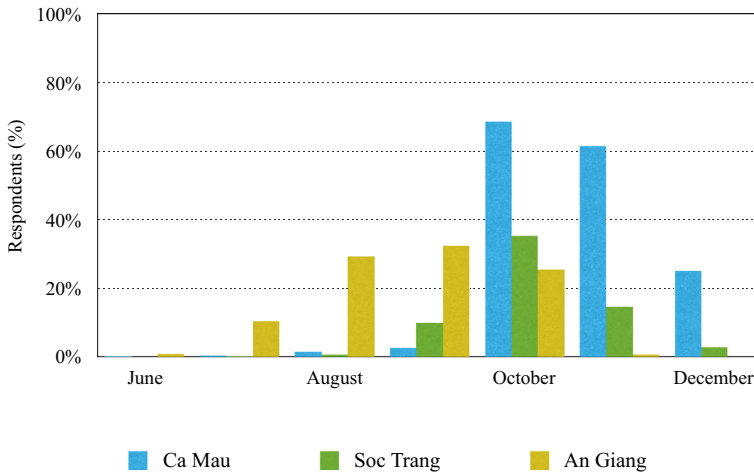
Over 75 % of the households interviewed in this survey are farmers in the agriculture sector, which includes both rice farming and aquaculture. (Table A.2). With the exception of residents in Binh Duc village in An Giang, all respondents regarded themselves as living in rural conditions.

The survey also shows that about three-quarters of the residents in An Giang and Soc Trang stated they made less than 2 million VND per month (Table A.2), a level that is regarded as poor by the Vietnam government (2010, 2012). This corresponds to levels shown in Table 1. On the other hand, while official records indicate Ca Mau residents as having the lowest average income among the three provinces, the survey results showed a larger proportion of Ca Mau residents who described themselves at higher income levels than either Soc Trang or An Giang. While no differentiation was made between rice farming and aquaculture, those working in the fishery sector, which dominates in Ca Mau, have substantially higher incomes.

#### 3.2 Characteristics of flood patterns

In order to properly understand the flooding profile in each province, residents were asked to describe which months they experienced the floods and the duration and height of these floods. Furthermore, we compare these results to scientific understanding of weather and hydrological patterns in each of the respective provinces. Floods in the Mekong Delta are complex due to multiple drivers: excessive freshwater flows due to increased river runoffs, storms and rain, and saltwater intrusion from tidal action. Figure 2 shows the months in which residents of each province typically experienced floods.

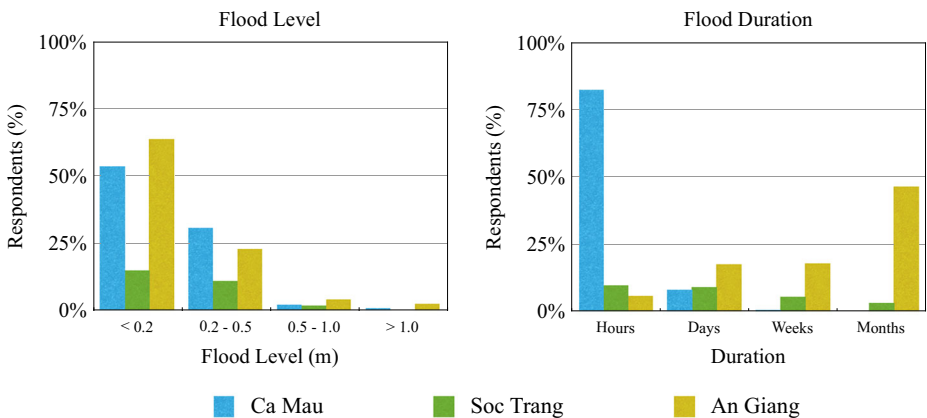
During the regular monsoon season, which starts in May, the Tien and Hau branches of the Mekong River swell continuously. This is consistent with the experiences of residents in An Giang province, and with rainfall decreasing after September, the flood season ends by November. On the other hand, in the coastal provinces of Soc Trang and Ca Mau floods, which are driven by torrential rain from typhoons that move in from the South China Sea, peak in October (Nguyen 2007). In Soc Trang's case, this corresponds with peak flooding along the Hau River, which flows along the northeast perimeter of the province, as well as the My Thanh



**Fig. 2** Months of occurrence of seasonal floods in An Giang, Soc Trang, and Ca Mau provinces. Percentage is out of 450 interviewed in each province

branch. Moreover, it is the start of the Chuong wind and high tide season, leading to frequent inundation (MONRE 2010).

Seasonal flood patterns are described in Fig. 3, which shows the level and the duration of floods experienced by households in our survey. In all three provinces floods do not usually exceed 0.2 m in height. While there are a significant number of floods observed between 0.2 m and 0.5 m, very few residences experienced floods higher than 0.5 m above ground level. However, the duration profile differs significantly among the provinces. Floods in Ca Mau generally last for only hours, while floods in An Giang tend to last for months. In Soc Trang’s case, most floods go on for hours or days but a significant proportion of them also last up to weeks and months.



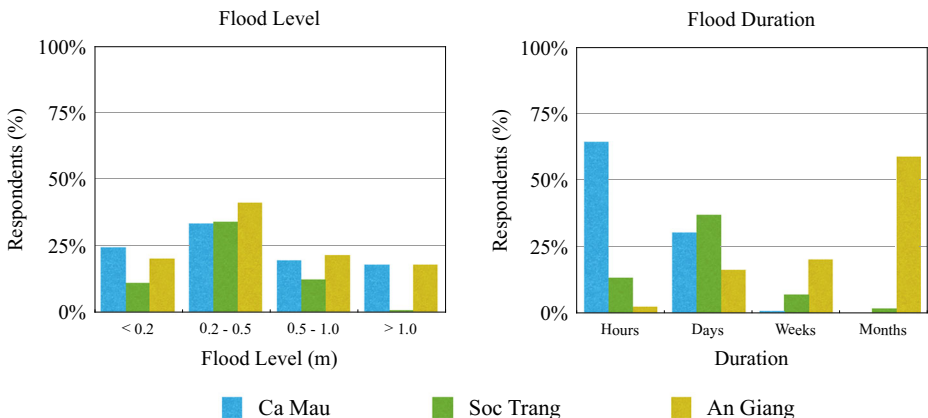
**Fig. 3** Level (*left*) and duration (*right*) of seasonal flooding typically observed around residences in Ca Mau, Soc Trang, and An Giang provinces of the Lower Mekong Delta. Percentage is out of 450 interviewed in each province

The observed level and duration of seasonal floods in each of the provinces are consistent with monsoon and torrential rain patterns. In terms of duration, Ca Mau's floods are unsurprisingly short and frequent. Moreover, they are driven by the two conflicting semi-diurnal tides of the East Sea (Tuan et al. 2008) and the West Sea, as well as brief but heavy afternoon downpours that occur daily throughout the season. In contrast, the flood depth and duration are higher and longer in An Giang due to monsoon-driven river swelling as the main source of flooding (UNDP 2008). This is further corroborated by remote sensing data, which shows deeper floods in the upstream regions of the Mekong Delta (Kuenzer et al. 2013). In the case of Soc Trang, the wider range of flood durations suggests a combined influence of river swelling and tidal cycles of the East Sea.

While average shifts in weather patterns due to climate change may not be perceptible, abrupt events stand out in people's memories. Thus, the residents were asked about their experience in extreme events, for example floods that fall out of the natural climate variability (Dolan and Walker 2006). In the survey, the interviewees were asked to describe flood events that stood out as the most destructive in their memory. It should be noted that the distinction between seasonal and extreme floods is subjective to each individual. Nevertheless, a comparison between the two gives a broad picture of changes that are attributable to climate change.

Figure 4 shows the profiles of flood events that were historically the worst in the respondents' memory. In terms of the flood heights, communes in all three provinces experienced higher levels than they did for seasonal floods. Floods with heights between 0.2 m to 0.5 m occurred at the highest frequency. In terms of duration, the profile for An Giang did not change much between seasonal and historical floods, but for provinces on the coast, historical floods lasted longer. For example, floods in Soc Trang tended to last days instead of hours.

Although located upstream, the historical flood levels in An Giang are higher due to SLR, which slows the discharge of water coming out of the Mekong River, causing rivers to swell even higher (Van 2011). SLR has now progressed to the degree that saline intrusion is being reported in An Giang. Along the coastal provinces, SLR is having a devastating effect in Soc Trang and Ca Mau; however, that alone does not explain the longer duration of the historical



**Fig. 4** Level (*left*) and duration (*right*) of historical flooding in the memory (between 1970 and 2012) of residents living in Ca Mau, Soc Trang, and An Giang provinces of the Lower Mekong Delta. Percentage is out of 450 interviewed in each province



floods. It is therefore necessary to find out when these events had occurred. Figure A.2 shows the year that corresponds to a respondents' memory of the year of historical flooding. In the case of Soc Trang and Ca Mau, almost all memory of historical flooding occurred in 1997 when tropical storm Linda, a category 1 typhoon, struck the Mekong Delta (World 2010b). The storm dropped heavy rainfall across southern Vietnam with up 9.17 in (23.3 cm) of rain. The damages included flooding in 4500 km<sup>2</sup> of rice paddy crop about half of which in Ca Mau along with 4000 people killed across the delta. Unlike torrential rains, the direct impact of a tropical storm can last days.

However, residents of An Giang province have little memory of this event. Due to the distance from the coast and the province's somewhat hilly terrain, they were shielded away from the typhoon. The recent floods of 2011 and 2012 in An Giang are due to swelling of the rivers, further suggesting riverine flooding as the main driver of floods in this province.

### 3.3 Exposure and adaptation to floods

Housing conditions are a major factor in how residents cope with floods. In an earlier study carried out in Central Vietnam (Kobayashi et al. 2012), it was found that households generally elevated their ground floors to avoid exposure to water. Both coastal and inland residents of the Mekong Delta are affected by annual flooding, but those who experienced extended flooding durations suffer the most as their homes become uninhabitable. In extreme cases, intense waves of water may wash out houses, along with the rice crops.

More than 98 % of the respondents in our survey stated living in one-storey houses, which is typical of households in the Lower Mekong Delta. Nevertheless, they are taking adaptation measures by elevating the ground level. Figure A.3 shows a distribution of the ground floor heights of the residents we interviewed. The homes in the coastal provinces tended to have ground floors greater than 0.2 m above ground while those in An Giang were not as highly elevated.

In order to gauge the exposure of residents in An Giang, Soc Trang, and Ca Mau to floods, we examined the residents' ability to remain dry during these events. Specifically, we examined the flood height relative to the ground floor level. The degree to which the ground floor was kept above the flood is taken as a proxy to how well they have adapted. Figure A.4 shows the relationship between ground floor (GF) elevation and floodwater levels (FL) in each of the provinces surveyed. Figure A.1 in the Appendix shows detailed analysis for one of the communes.

Among the provinces surveyed, our comparison shows that villages and communes in Ca Mau are the least exposed to seasonal flooding. Around three-quarters of the residents were able to stay above flood waters as they had sufficiently elevated their ground floors. Soc Trang also showed similar degree of adaptation. In contrast, less than 40 % of homes in An Giang are able to stay dry during the annual flood season and nearly 20 % of them were overflowed during floods.

With very few exceptions, respondents in all three provinces noted that extreme flooding was equal or longer in duration, and equal or deeper in height than seasonal floods. In Ca Mau, the ratio of homes that stays above water drops to 40 % with rates in Soc Trang and An Giang at 15 % and 10 %, respectively. Moreover, over half of the households in An Giang experienced water on their ground floor during extreme floods.

A review of the housing situation shows that residents in each province have already adapted to flooding to various degrees. An Giang has arguably the highest exposure due to

higher incidence of the water level exceeding the ground floor in both seasonal and extreme floods. At the same time, Ca Mau residents have a higher proportion of homes that can stay above flood levels. In order to understand whether these experiences can translate into awareness for taking proper adaptation measures, this survey also aimed to ascertain the perception of flood patterns.

### 3.4 Perception of flood dynamics

How residents and communities view the risks associated with natural disasters can inform their actions to improve resilience. However, the perception of risk often do not match actual risk as some studies suggest (DWF 2011). Indeed, while perceptions can be affected by sampling bias or local factors, they can still provide insight into relative changes.

Figure A.5 shows the perception of residents on the frequency and the intensity of floods, which demonstrate nearly identical trends. Among the three provinces, the residents of Ca Mau sense the greatest increase in frequency and intensity of floods with over 80 % reporting increasing trends. In An Giang's case, not only do fewer respondents feel the threat of floods to be increasing, over 30 % are feeling a decrease in overall frequency and intensity of the floods.

Therefore, among the three provinces, residents of Ca Mau sense the greatest perceived risk while those in An Giang sense the least. This is consistent with our observations on flood adaptation (Figure A.3), which shows Ca Mau residents elevating their ground floors the most and An Giang residents the least.

Properly distinguishing natural variability from long-term climate change remains a major challenge (Hansen et al. 2012). Although this question was asked in the context of various types of natural disasters, including storms, lighting, erosion, saline intrusion, and drought, respondents in all three provinces perceived greater risk to extreme flooding than they did to seasonal flooding (Figure A.6). While extreme flooding can be indicative of climate change, the respondents do not necessarily see a link, based on their perceptions. Nevertheless, the observed increase in frequency and intensity of the floods are consistent with the effects of climate change.

Though the findings among the three provinces are similar, residents in Ca Mau showed the strongest sensitivity to extreme flooding with 20 % more respondents describing these floods to be “most risk” than in Soc Trang or An Giang. This implies that SLR and rain driven floods are perceived to be more intense.

### 3.5 Linkages between exposure, adaptation, and perception

While the relationship between the perceived risk and the degree of flood adaptation is established above, the link between perceived risk and actual risk, which is defined as a function of exposure and sensitivity (Smit and Wandel 2006), is not clear. To truly understand the vulnerability of these communities, sensitivity and adaptive capacity must also be assessed (Adger 2006, ADB and AusAid 2011). As a result of each province's respective adaptation measures, the exposure to flooding is inversely correlated to their effort in adaptation. While Ca Mau residents perceive the greatest risk, they are also the least exposed. The converse is true for An Giang where perceived risk is the least and exposure is the greatest. While adaptation efforts are generally directed to areas that have the most exposure, the survey shows that to be after the fact. It is arguable that Ca Mau residents have adapted more because they perceive greater risks and are therefore the least exposed. While a sensitivity analysis was

not carried out in this study, socioeconomic factors such as income inequality and level of poverty play a role in the sensitivity to climate change (Adger 1999). Ca Mau's relative lower per capita income (Table 1) can be one factor in why the residents sense higher risks. Although actual and perceived risks could not be compared, we have identified psychological and cultural factors that underlie both local sensitivity and perception.

The temporal aspects (frequency, duration, and suddenness) of natural disasters like flooding can play a role in how climate change is perceived and how adaptation measures are developed (Smithers and Smit 1997). Among these qualities, suddenness, which describes the onset of climate events, may play an important role in how flood risk is perceived in Ca Mau. The higher perception of flooding intensity and frequency in Ca Mau can be attributed to the nature of its floods, which are tidal. An increase in its perceived intensity and frequency is amplified by the punctuated nature and shorter cycles of these types of floods. In contrast, the gradual change in the duration and height of water levels due to river flooding in An Giang may not be as easily sensed, leading to lower perceived risks. The responses of Soc Trang's residents are between those of Ca Mau's and An Giang's, which suggests influence from both river flooding and SLR.

Another complication lies in how floods are defined. In the Vietnamese language, floods can be classified as *lu* (flood), *lut* (inundation), *ngap* (submergence), and *bao lu* (storm flood) (Tuan et al. 2008). As the survey did not distinguish between different types of floods, the responses are likely to be subjective. Both rice farmers and fishermen depend on freshwater and saltwater floods, respectively, for their livelihoods, and not unexpectedly they regard higher water levels in a positive way. For example, Ca Mau residents look forward to floods to increase their fish catch.

### 3.6 Strategies for climate proofing

According to records kept between the 1950s and 1990s, the number of heavy storms and typhoons lasting until late autumn in Vietnam has increased, with the peak month shifting from August to November (Dang et al. 2013). Scientific models predict that torrential rainfalls and flash floods from these storms will increase both in number and in intensity due to climate change (Nguyen 2007), compounded by the effects of SLR. Furthermore, numerous studies show climate change induced damages to housing and agriculture due to flooding will become more extensive in the Mekong Delta (Wassmann et al. 2004; Nhan et al. 2011). In coastal zones, existing dykes and other structural elements built to control floods and manage water supplies will not be able to hold back seawater and tides as SLR becomes more severe.

In this study, we have examined the heightening of the ground floors as an indicator of adaptation. However, other counter-measures also contribute to adaptation. Table A.3 shows the adaptation strategies that residents are already employing or intend to employ. At least three-quarters of the residents in the three provinces are aware of at least one approach to cope with floods. Among these strategies, reinforcement of the houses is the most widely recognized. While building two-storey residences would be the most direct approach, this strategy is prohibitively expensive.

The availability of boats for private transportation is another indicator of adaptation in rural households, whose access to civil and medical services would be severely limited during disasters. In this respect, the residents of Soc Trang have additional coping capacity with their greater access to boats than those in the other two provinces. However, it should be noted that public boat transportation is already widely available in Ca Mau and that many residents also own boats to get around the canals.

### 3.7 Barriers to rural adaptation

Our survey of rural residents in the Lower Mekong Delta shows a strong awareness of the worsening damage that floods cause and the measures needed to cope with these threats. Nevertheless, the population of the delta continues to grow, with strong growth in An Giang and Ca Mau. Both the socioeconomic situation of the residents and the government's top-down approach limit rural communities to adapt.

Although rice farmers face natural and man-made disasters, they have few options to move away from flood-prone areas (Wassmann et al. 2004). There is an overwhelming economic incentive to intensify farming and aquaculture as the national government continues to build dykes and strengthen existing ones to control flood inundation. In 2012, VND164 billion (US\$7.8 million) was spent in An Giang province to dredge canals and upgrade dykes and sluice gates (MONRE 2010). For example, the success of these programs has resulted in a doubling of crop yields in An Phu district. Consequently, a third crop of rice in the autumn-winter season is becoming common, often in areas surrounded by weak dykes (DWF 2011). Similarly, overfishing is regularly observed in the aquaculture sector (Ha and van Dijk 2013).

While authorities continue to flood-proof high risk areas, progress has been slow (DTI News 2012) due to the slow allocation of capital. This has been exacerbated by price increases, resulting in higher implementation costs than originally anticipated. Furthermore, the centralized nature of governance does not allow for inputs from households into their planning. As a result, local concerns are not adequately reflected in the central government's land-use planning and infrastructure development.

## 4 Conclusion

This study has shown the complexities of adaptive processes and the cultural context needed to analyze these subjects. Although we attempted to find a relationship between the residents' adaptive capacity to factors such as profession, distance to water, age of home, and income, no correlation could be discerned.

In spite of a tendency to regard the Mekong Delta as a flat basin with a uniform environment, there is in fact a wide diversity of geographical, hydrological, and meteorological conditions that influence local exposure to floods. In this study, we conducted a questionnaire survey to profile flood conditions and housing adaptation in three distinct regimes of the Mekong Delta: upstream province with flat topography (An Giang), downstream province directly impacted by SLR (Soc Trang), salty marshland with heavy torrential rain and high tides (Ca Mau). Among the provinces, Ca Mau showed the least exposure to seasonal flooding while An Giang showed the greatest exposure.

While the findings of this study are consistent with top-down scientific understanding of the hydrological and meteorological patterns in the Mekong Delta, the household approach in this study showed the context-specific nature of risk and adaptation (Smit and Wandel 2006). Furthermore, residents in all three provinces have been observing increasing frequencies and intensities in floods, a trend that is consistent with climate change. They also sense higher risk in extreme floods than they do in seasonal floods.

While a positive correlation could be drawn between flood perception and adaptation effort, the exposure to flooding was consequently inversely related to perception. To truly understand the vulnerability of these communities, future studies should also assess the factors that

underlie awareness and sensitivity to climate change. It has been found that flood duration and intensity, as well as local definitions of what constitutes a flood, can shape a community's perception of the impacts of natural disaster. Furthermore, these types of surveys should be designed with better sampling to reduce bias and to improve the response rate.

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